

14230

012804

Please type a plus sign (+) inside this box → | + |

PTO/SB/05 (01-04)

U.S. PTO

80727 USPTO

012804

CERTIFICATE OF MAILING OR TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as Express Mail (label number EV 387840809 US) in an envelope addressed to: Mail Stop PATENT APPLICATION, Commissioner for Patents, PO Box 1450, Alexandria, VA 22313-1450 under the provisions of 37 CFR §1.10.

Mailer's Name (Print/Type)	Katrina Holland	Signature	Katrina Holland	Date	1/28/2004
----------------------------	-----------------	-----------	-----------------	------	-----------

UTILITY PATENT APPLICATION TRANSMITTAL <i>(Only for new nonprovisional applications under 37 CFR 1.53(b))</i>	Attorney Docket No.	4213-104
	First Inventor	AKER, John F., et al.
	Title	THERMAL MANAGEMENT OF FAST CHARGING HIGH CAPACITY BATTERIES
	Express Mail Label No.	EV 387840809 US

APPLICATION ELEMENTS <i>See MPEP chapter 600 concerning utility patent application contents.</i>		ADDRESS TO: Mail Stop Patent Application Commissioner for Patents P.O. Box 1450 Alexandria, VA 22313-1450
1. <input checked="" type="checkbox"/> Fee Transmittal Form (e.g., PTO/SB/17) <i>(Submit an original and a duplicate for fee processing)</i> 2. <input checked="" type="checkbox"/> Applicant claims small entity status. <i>See 37 CFR 1.27.</i> 3. <input checked="" type="checkbox"/> Specification [Total Pages 33] <i>(preferred arrangement set forth below)</i> - Descriptive title of the invention - Cross Reference to Related Applications - Statement Regarding Fed sponsored R & D - Reference to sequence listing, a table, or a computer program listing appendix - Background of the Invention - Brief Summary of the Invention - Brief Description of the Drawings <i>(if filed)</i> - Detailed Description - Claim(s) - Abstract of the Disclosure 4. <input checked="" type="checkbox"/> Drawing(s) (35 U.S.C. 113) [Total Sheets 16] 5. Oath or Declaration [Total Sheets 2] a. <input checked="" type="checkbox"/> Newly executed (copy) b. <input type="checkbox"/> Copy from a prior application (37 CFR 1.63 (d)) <i>(for continuation/divisional with Box 18 completed)</i> i. <input type="checkbox"/> DELETION OF INVENTOR(S) <i>Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).</i> 6. <input type="checkbox"/> Application Data Sheet. See 37 CFR 1.76		
7. <input type="checkbox"/> CD-ROM or CD-R in duplicate, large table or Computer Program (Appendix) 8. Nucleotide and/or Amino Acid Sequence Submission <i>(if applicable, all necessary)</i> a. <input type="checkbox"/> Computer Readable Form (CRF) b. Specification Sequence Listing on: i. <input type="checkbox"/> CD-ROM or CD-R (2 copies); or ii. <input type="checkbox"/> paper c. <input type="checkbox"/> Statements verifying identity of above copies		
ACCOMPANYING APPLICATION PARTS 9. <input checked="" type="checkbox"/> Assignment Papers (cover sheet & document(s)) 10. <input type="checkbox"/> 37 CFR 3.73(b) Statement <input type="checkbox"/> Power of Attorney <i>(when there is an assignee)</i> 11. <input type="checkbox"/> English Translation Document <i>(if applicable)</i> 12. <input type="checkbox"/> Information Disclosure Statement (IDS)/PTO-1449 <input type="checkbox"/> Copies of IDS Citations 13. <input type="checkbox"/> Preliminary Amendment 14. <input checked="" type="checkbox"/> Return Receipt Postcard (MPEP 503) <i>(Should be specifically itemized)</i> 15. <input type="checkbox"/> Certified Copy of Priority Document(s) <i>(if foreign priority is claimed)</i> 16. <input type="checkbox"/> Nonpublication Request under 35 U.S.C. 122(b)(2)(B)(i). 17. <input type="checkbox"/> Other:		

18. If a CONTINUING APPLICATION, check appropriate box, and supply the requisite information below and in the first sentence of the specification following the title, or in an Application Data Sheet under 37 CFR 1.76:

Continuation Divisional Continuation-in-part (CIP) of prior application No.: _____

Prior application information: Examiner _____ Art Unit: _____
For CONTINUATION or DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference.
 The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

19. CORRESPONDENCE ADDRESS

<input checked="" type="checkbox"/> Customer Number:	23448	<input type="checkbox"/> OR	<input type="checkbox"/> Correspondence address below
Name	Intellectual Property Technology Law		
Address			
City	State	Zip Code	
Country	US	Telephone	(919) 419-9350
Telephone	(919) 419-9350	Fax	(919) 419-9354
Name (Print/type)	Steven J. Hultquist	Registration No. (Attorney/Agent)	28021
Signature	1/28/2004		

23448

012804

PTO/SB/17 (10-03)

Approved for use through 07/31/2006. OMB 0651-0032
U.S. Patent and Trademark Office: U.S. DEPARTMENT OF COMMERCE

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

FEE TRANSMITTAL for FY 2004

Effective 10/01/2003. Patent fees are subject to annual revision.

 Applicant Claims small entity status. See 37 CFR 1.27

TOTAL AMOUNT OF PAYMENT (\$ 542.00)

Complete if Known

Application Number	New Application
Filing Date	January 28, 2004
First Named Inventor	AKER, John F., et al.
Examiner Name	Unassigned
Art Unit	Unassigned
Attorney Docket No.	4213-104

METHOD OF PAYMENT (check all that apply)		FEE CALCULATION (continued)																																																																																																																																																																																																																					
<input type="checkbox"/> Check <input checked="" type="checkbox"/> Credit card <input type="checkbox"/> Money Order <input type="checkbox"/> Other <input type="checkbox"/> None <input checked="" type="checkbox"/> Deposit Account Deposit Account Number 083284 Deposit Account Name Intellectual Property Technology Law		3. ADDITIONAL FEES <table border="1"> <thead> <tr> <th>Large Entity</th> <th>Small Entity</th> <th colspan="3">Fee Description</th> <th>Fee Paid</th> </tr> <tr> <th>Fee Code (\$)</th> <th></th> </tr> </thead> <tbody> <tr> <td>1051</td> <td>130</td> <td>2051</td> <td>65</td> <td>Surcharge – late filing fee or oath</td> <td></td> </tr> <tr> <td>1052</td> <td>50</td> <td>2052</td> <td>25</td> <td>Surcharge – late provisional filing fee or cover sheet</td> <td></td> </tr> <tr> <td>1053</td> <td>130</td> <td>1053</td> <td>130</td> <td>Non-English specification</td> <td></td> </tr> <tr> <td>1812</td> <td>2,520</td> <td>1812</td> <td>2,520</td> <td>For filing a request for ex parte reexamination</td> <td></td> </tr> <tr> <td>1804</td> <td>920*</td> <td>1804</td> <td>920*</td> <td>Requesting publication of SIR prior to Examiner action</td> <td></td> </tr> <tr> <td>1805</td> <td>1,840*</td> <td>1805</td> <td>1,840*</td> <td>Requesting publication of SIR after Examiner action</td> <td></td> </tr> <tr> <td>1251</td> <td>110</td> <td>2251</td> <td>55</td> <td>Extension for reply within first month</td> <td></td> </tr> <tr> <td>1252</td> <td>420</td> <td>2252</td> <td>210</td> <td>Extension for reply within second month</td> <td></td> </tr> <tr> <td>1253</td> <td>950</td> <td>2253</td> <td>475</td> <td>Extension for reply within third month</td> <td></td> </tr> <tr> <td>1254</td> <td>1,480</td> <td>2254</td> <td>740</td> <td>Extension for reply within fourth month</td> <td></td> </tr> <tr> <td>1255</td> <td>2,010</td> <td>2255</td> <td>1,005</td> <td>Extension for reply within fifth month</td> <td></td> </tr> <tr> <td>1401</td> <td>330</td> <td>2401</td> <td>165</td> <td>Notice of Appeal</td> <td></td> </tr> <tr> <td>1402</td> <td>330</td> <td>2402</td> <td>165</td> <td>Filing a brief in support of an appeal</td> <td></td> </tr> <tr> <td>1403</td> <td>290</td> <td>2403</td> <td>145</td> <td>Request for oral hearing</td> <td></td> </tr> <tr> <td>1451</td> <td>1,510</td> <td>1451</td> <td>1,510</td> <td>Petition to institute a public use proceeding</td> <td></td> </tr> <tr> <td>1452</td> <td>110</td> <td>2452</td> <td>55</td> <td>Petition to revive – unavoidable</td> <td></td> </tr> <tr> <td>1453</td> <td>1,330</td> <td>2453</td> <td>665</td> <td>Petition to revive – unintentional</td> <td></td> </tr> <tr> <td>1501</td> <td>1,330</td> <td>2501</td> <td>665</td> <td>Utility issue fee (or reissue)</td> <td></td> </tr> <tr> <td>1502</td> <td>480</td> <td>2502</td> <td>240</td> <td>Design issue fee</td> <td></td> </tr> <tr> <td>1503</td> <td>640</td> <td>2503</td> <td>320</td> <td>Plant issue fee</td> <td></td> </tr> <tr> <td>1460</td> <td>130</td> <td>1460</td> <td>130</td> <td>Petitions to the Commissioner</td> <td></td> </tr> <tr> <td>1807</td> <td>50</td> <td>1807</td> <td>50</td> <td>Processing fee under 37 CFR 1.17(q)</td> <td></td> </tr> <tr> <td>1806</td> <td>180</td> <td>1806</td> <td>180</td> <td>Submission of Information Disclosure Stmt</td> <td></td> </tr> <tr> <td>8021</td> <td>40</td> <td>8021</td> <td>40</td> <td>Recording each patent assignment per property (times number of properties)</td> <td>40.00</td> </tr> <tr> <td>1809</td> <td>770</td> <td>2809</td> <td>385</td> <td>Filing a submission after final rejection (37 CFR 1.129(a))</td> <td></td> </tr> <tr> <td>1810</td> <td>770</td> <td>2810</td> <td>385</td> <td>For each additional invention to be examined (37 CFR 1.129(b))</td> <td></td> </tr> <tr> <td>1801</td> <td>770</td> <td>2801</td> <td>385</td> <td>Request for Continued Examination (RCE)</td> <td></td> </tr> <tr> <td>1802</td> <td>900</td> <td>1802</td> <td>900</td> <td>Request for expedited examination of a design application</td> <td></td> </tr> <tr> <td colspan="4">Other fee (specify) _____</td> <td colspan="2"></td> </tr> <tr> <td colspan="4">*Reduced by Basic Filing Fee Paid</td> <td colspan="2">SUBTOTAL (3) (\$ 40.00)</td> </tr> <tr> <td colspan="6">SUBMITTED BY Complete (if applicable)</td> </tr> <tr> <td>Name (Print/Type)</td> <td>Steven J. Hultquist </td> <td>Registration No. (Attorney/Agent)</td> <td>28021</td> <td>Telephone</td> <td>(919) 419-9350</td> </tr> <tr> <td>Signature</td> <td></td> <td></td> <td></td> <td>Date</td> <td>1/28/2004</td> </tr> </tbody> </table>				Large Entity	Small Entity	Fee Description			Fee Paid	Fee Code (\$)		1051	130	2051	65	Surcharge – late filing fee or oath		1052	50	2052	25	Surcharge – late provisional filing fee or cover sheet		1053	130	1053	130	Non-English specification		1812	2,520	1812	2,520	For filing a request for ex parte reexamination		1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action		1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action		1251	110	2251	55	Extension for reply within first month		1252	420	2252	210	Extension for reply within second month		1253	950	2253	475	Extension for reply within third month		1254	1,480	2254	740	Extension for reply within fourth month		1255	2,010	2255	1,005	Extension for reply within fifth month		1401	330	2401	165	Notice of Appeal		1402	330	2402	165	Filing a brief in support of an appeal		1403	290	2403	145	Request for oral hearing		1451	1,510	1451	1,510	Petition to institute a public use proceeding		1452	110	2452	55	Petition to revive – unavoidable		1453	1,330	2453	665	Petition to revive – unintentional		1501	1,330	2501	665	Utility issue fee (or reissue)		1502	480	2502	240	Design issue fee		1503	640	2503	320	Plant issue fee		1460	130	1460	130	Petitions to the Commissioner		1807	50	1807	50	Processing fee under 37 CFR 1.17(q)		1806	180	1806	180	Submission of Information Disclosure Stmt		8021	40	8021	40	Recording each patent assignment per property (times number of properties)	40.00	1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))		1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))		1801	770	2801	385	Request for Continued Examination (RCE)		1802	900	1802	900	Request for expedited examination of a design application		Other fee (specify) _____						*Reduced by Basic Filing Fee Paid				SUBTOTAL (3) (\$ 40.00)		SUBMITTED BY Complete (if applicable)						Name (Print/Type)	Steven J. Hultquist 	Registration No. (Attorney/Agent)	28021	Telephone	(919) 419-9350	Signature				Date	1/28/2004				
Large Entity	Small Entity	Fee Description			Fee Paid																																																																																																																																																																																																																		
Fee Code (\$)	Fee Code (\$)	Fee Code (\$)	Fee Code (\$)	Fee Code (\$)																																																																																																																																																																																																																			
1051	130	2051	65	Surcharge – late filing fee or oath																																																																																																																																																																																																																			
1052	50	2052	25	Surcharge – late provisional filing fee or cover sheet																																																																																																																																																																																																																			
1053	130	1053	130	Non-English specification																																																																																																																																																																																																																			
1812	2,520	1812	2,520	For filing a request for ex parte reexamination																																																																																																																																																																																																																			
1804	920*	1804	920*	Requesting publication of SIR prior to Examiner action																																																																																																																																																																																																																			
1805	1,840*	1805	1,840*	Requesting publication of SIR after Examiner action																																																																																																																																																																																																																			
1251	110	2251	55	Extension for reply within first month																																																																																																																																																																																																																			
1252	420	2252	210	Extension for reply within second month																																																																																																																																																																																																																			
1253	950	2253	475	Extension for reply within third month																																																																																																																																																																																																																			
1254	1,480	2254	740	Extension for reply within fourth month																																																																																																																																																																																																																			
1255	2,010	2255	1,005	Extension for reply within fifth month																																																																																																																																																																																																																			
1401	330	2401	165	Notice of Appeal																																																																																																																																																																																																																			
1402	330	2402	165	Filing a brief in support of an appeal																																																																																																																																																																																																																			
1403	290	2403	145	Request for oral hearing																																																																																																																																																																																																																			
1451	1,510	1451	1,510	Petition to institute a public use proceeding																																																																																																																																																																																																																			
1452	110	2452	55	Petition to revive – unavoidable																																																																																																																																																																																																																			
1453	1,330	2453	665	Petition to revive – unintentional																																																																																																																																																																																																																			
1501	1,330	2501	665	Utility issue fee (or reissue)																																																																																																																																																																																																																			
1502	480	2502	240	Design issue fee																																																																																																																																																																																																																			
1503	640	2503	320	Plant issue fee																																																																																																																																																																																																																			
1460	130	1460	130	Petitions to the Commissioner																																																																																																																																																																																																																			
1807	50	1807	50	Processing fee under 37 CFR 1.17(q)																																																																																																																																																																																																																			
1806	180	1806	180	Submission of Information Disclosure Stmt																																																																																																																																																																																																																			
8021	40	8021	40	Recording each patent assignment per property (times number of properties)	40.00																																																																																																																																																																																																																		
1809	770	2809	385	Filing a submission after final rejection (37 CFR 1.129(a))																																																																																																																																																																																																																			
1810	770	2810	385	For each additional invention to be examined (37 CFR 1.129(b))																																																																																																																																																																																																																			
1801	770	2801	385	Request for Continued Examination (RCE)																																																																																																																																																																																																																			
1802	900	1802	900	Request for expedited examination of a design application																																																																																																																																																																																																																			
Other fee (specify) _____																																																																																																																																																																																																																							
*Reduced by Basic Filing Fee Paid				SUBTOTAL (3) (\$ 40.00)																																																																																																																																																																																																																			
SUBMITTED BY Complete (if applicable)																																																																																																																																																																																																																							
Name (Print/Type)	Steven J. Hultquist 	Registration No. (Attorney/Agent)	28021	Telephone	(919) 419-9350																																																																																																																																																																																																																		
Signature				Date	1/28/2004																																																																																																																																																																																																																		

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

This collection of information is required by 37 CFR 1.17 and 1.27. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

BRIEF DESCRIPTION OF THE DRAWINGS

**Fig. 1 is a view of an electron microscope photograph on a
filmy object of the present invention in the Example 1.**

5 **Fig. 2 is a view of an electron microscope photograph of the
surface of the film surface on the electrolyte solution side on a filmy
object of the present invention in the Comparative Example 1.**

BEST MODES FOR CARRYING OUT THE INVENTION

10 **The present invention is a filmy object containing an
electrically conductive polymer, characterized in that**

**(1) the electrically conductive polymer is one obtained by the
electrolytic polymerization method and**

15 **(2) upon immersion in a good solvent, the filmy object expands
to come to have a film surface area larger by 30% or more than the
film surface area before the immersion. Because of containing an
electrically conductive polymer obtained by the electrolytic
polymerization method, the aforesaid filmy object is excellent in
physical properties, and can swell largely by a solvent, so that the
filmy object can function as a gel polymer. Also, since the filmy
20 object can incorporate and release large functional molecules that are
in an ion form, the filmy object can be used as a functional film.**

25 **The filmy object of the present invention contains an
electrically conductive polymer obtained by the electrolytic
polymerization method and, moreover, when the filmy object is
immersed in a good solvent, the filmy object expands to come to have
a film surface area larger by 30% or more than the film surface area
before the immersion. In other words, the filmy object of the present
invention can easily incorporate and release ions of functional
molecules as a dopant because the filmy object has a property of
30 swelling upon immersion in a good solvent and expanding to come to**

have a film surface area larger by 30% or more than the film surface area before the immersion. For this reason, the filmy object of the present invention can be used as a functional film even though it is a filmy object containing an electrically conductive polymer obtained by the electrolytic polymerization method and having large ions as a dopant. In order that the aforesaid filmy object can incorporate and release more numerous functional molecules and/or easily incorporate and release functional molecules, the increase in the surface area of the film surface of the filmy object is preferably 60% or more, more preferably 80% or more, still more preferably 100% or more, as compared with that before the immersion. Here, the aforesaid swelling is such that the filmy object retains a shape analogous to the shape before swelling, or a shape similar to the shape before swelling, so that it does not include coming to have a state of not being able to maintain the shape. Also, the aforesaid swelling is a finite swelling, so that it does not include an infinite swelling by which the filmy object comes to be dissolved.

The aforesaid good solvent means a solvent that swells the filmy object, and is not particularly limited. However, the aforesaid good solvent is preferably a polar organic solvent such as represented by propylene carbonate, acetone, ethanol, 1,2-diethoxyethane, 1-methyl-2-pyrrolidone, and dimethyl sulfoxide, and is more preferably propylene carbonate and acetone. Propylene carbonate is excellent in the solubility of ions, and is excellent as a solvent in carrying out the doping and dedoping. Also, acetone is a representative polar organic solvent, and is suitably used in peeling off the electrically conductive polymer obtained by the electrolytic polymerization method from the working electrode. Namely, an electrically conductive polymer having acetone as a good solvent is easily peeled off from the working electrode, and is excellent in the

production workability.

The aforesaid good solvent is used for showing the film property of the filmy object of the present invention, and need not coincide with solvents that are present in the environment in which the 5 filmy object is used as a functional film. However, in order that the filmy object of the present invention can incorporate and release larger functional molecules and/or easily incorporate and release functional molecules, the doping and dedoping of the ions of the functional molecules is preferably carried out in the aforesaid good solvent so as to allow the filmy object to function as a functional film.

The 10 filmy object of the present invention contains an electrically conductive polymer obtained by the electrolytic polymerization method. As the aforesaid electrolytic polymerization method, a known electrolytic polymerization method can be used, where a 15 working electrode and an opposing electrode thereof are disposed in an electrolyte solution containing an electrically conductive polymer monomer. For the aforesaid electrolytic polymerization method, regarding the physical polymerization condition, any of the constant-potential method, the 20 constant-current method, and the electric sweeping method can be used. For example, the aforesaid electrolytic polymerization method can be carried out at an electric current density of 0.01 to 20 mA/cm² and a reaction temperature of -70 to 80°C. In order to obtain an electrically conductive polymer having a good film quality, the 25 electrolytic polymerization method is preferably carried out under a condition with an electric current density of 0.1 to 2 mA/cm² and a reaction temperature of -40 to 40°C, more preferably under a condition with a reaction temperature of -30 to 30°C.

In the above-described electrolytic polymerization method, the 30 solvent to be used as an electrolyte solution is not particularly

limited as long as the solvent can dissolve a predetermined amount or more of the electrolyte contained in the electrolyte solution. As the aforesaid solvent, it is preferable to use an organic compound and or a halogenated hydrocarbon containing at least one or more bonds or 5 functional groups among an ether bond, an ester bond, a carbonate bond, a hydroxyl group, a nitro group, a sulfone group, and a nitrile group, in order to obtain a film having a good quality. Two or more kinds of these solvents may be used in combination. Also, when 10 being dry, the film is a porous film having a sponge form, so that the specific surface area is large, thereby facilitating the adsorption and release of specific molecules and substances.

Examples of the aforesaid organic compounds include 1,2-dimethoxyethane, 1,2-diethoxyethane, tetrahydrofuran, 15 2-methyltetrahydrofuran, 1,4-dioxane (the above being organic compounds containing an ether bond), γ -butyrolactone, ethyl acetate, n-butyl acetate, t-butyl acetate, 1,2-diacetoxyethane, 3-methyl-2-oxazolidinone, methyl benzoate, ethyl benzoate, butyl benzoate, diethyl phthalate (the above being organic compounds containing an ester bond), propylene carbonate, ethylene carbonate, 20 dimethyl carbonate, diethyl carbonate, methyl ethyl carbonate, (the above being organic compounds containing a carbonate bond), ethylene glycol, 1-butanol, 1-hexanol, cyclohexanol, 1-octanol, 1-decanol, 1-dodecanol, 1-octadecanol (the above being organic compounds containing a hydroxyl group), nitromethane, nitrobenzene 25 (the above being organic compounds containing a nitro group), sulfolane, dimethylsulfone (the above being organic compounds containing a sulfone group), and acetonitrile, butyronitrile, benzonitrile (the above being organic compounds containing a nitrile group). Here, the organic compound containing a hydroxyl group is 30 not particularly limited; however, it is preferably a polyhydric alcohol

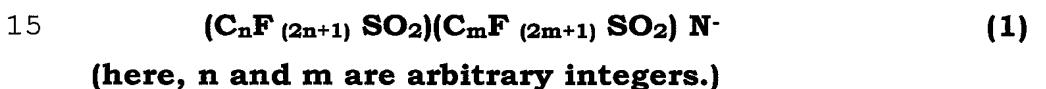
or a monohydric alcohol having a carbon number of 4 or more, because then the film quality will be good. Here, besides the examples raised above, the aforesaid organic compound may be an organic compound containing two or more bonds or functional groups 5 among an ether bond, an ester bond, a carbonate bond, a hydroxyl group, a nitro group, a sulfone group, and a nitrile group in any combination in a molecule.

Also, in the method of producing an electrically conductive polymer of the present invention, the halogenated hydrocarbon contained as a solvent in the electrolyte solution is not particularly limited as long as it is one in which at least one or more hydrogen in the hydrocarbon is substituted with a halogen atom and can exist stably in a liquid form under an electrolytic polymerization condition. 10 As the aforesaid halogenated hydrocarbon, dichloromethane and dichloroethane can be raised as examples. Though it is possible to use one kind of the aforesaid halogenated hydrocarbon alone as a solvent in the aforesaid electrolyte solution, it is also possible to use two or more kinds in combination. Also, the aforesaid halogenated hydrocarbon may be used as a mixture with the above-described 15 organic compound, and the mixed solvent mixed with the organic solvent may be used as a solvent in the aforesaid electrolyte solution. 20

In the electrolyte solution used in the aforesaid electrolytic polymerization method, the monomer of an electrically conductive polymer contained in the electrolyte solution used in the electrolytic polymerization method is not particularly limited as long as it is a compound that is polymerized by oxidation through electrolytic polymerization to exhibit electric conductivity. For example, 25 five-membered heterocyclic compounds such as pyrrole, thiophene, and isothianaphthene, and the derivatives thereof with alkyl group or oxyalkyl group may be raised. Among these, five-membered 30

heterocyclic compounds such as pyrrole and thiophene, and the derivatives thereof are preferable. Particularly, it is preferably an electrically conductive polymer containing pyrrole and/or a pyrrole derivative because then the production will be easy and it will be stable as an electrically conductive polymer. Also, two or more kinds of the aforesaid monomers may be used in combination.

It is preferable that the electrolyte contained in the electrolyte solution used in the aforesaid electrolytic polymerization method contains perfluoroalkylsulfonylimide ion represented by the following chemical formula (1), because then it will be easy to obtain an electrically conductive polymer such that the filmy object, upon immersion in a good solvent, expands to come to have a film surface area larger by 30% or more than the film surface area before the immersion.



In a filmy object containing an electrically conductive polymer obtained by the electrolytic polymerization method obtained by the electrolytic polymerization method using an electrolyte solution containing the aforesaid perfluoroalkylsulfonylimide ion, the aforesaid anion is present within a bulk. The aforesaid anion has a larger molecule size as compared with conventional dopants such as perchlorate ion and trifluoromethanesulfonate ion. For this reason, the aforesaid electrically conductive polymer releases the aforesaid perfluoroalkylsulfonylimide ion by dedoping, and can easily incorporate a larger functional polymer. Also, by the electrolytic polymerization method that uses an electrolyte solution containing the aforesaid perfluoroalkylsulfonylimide ion, one can easily obtain a filmy object having a plurality of holes that are formed in a porous form on the film surface and being provided with holes such that the

shorter diameter of the aforesaid holes at the opening is 0.5 μ m or more at the time of being dry.

The aforesaid perfluoroalkylsulfonylimide ion has a sulfonyl group bonded to a nitrogen atom serving as an anion center, and further has two perfluoroalkyl groups which are substituents. This perfluoroalkylsulfonyl is represented by $C_nF_{(2n+1)}SO_2$, and the other perfluoroalkylsulfonyl group is represented by $C_mF_{(2m+1)}SO_2$. The aforesaid n and m are arbitrary integers respectively being 1 or more. The numbers n and m may be the same integer, or the numbers n and m may be different integers. For example, trifluoromethyl group, pentafluoroethyl group, heptafluoropropyl group, nonafluorobutyl group, undecafluoropentyl group, tridecafluorohexyl group, pentadecafluoroheptyl group, and heptadecafluoroctyl group may be raised. As the aforesaid perfluoroalkylsulfonylimide salt, for example, bistrifluoromethylsulfonylimide salt, bis(pentafluoroethylsulfonyl)imide salt, and bis(heptadecafluoroctylsulfonyl)imide salt can be used.

The perfluoroalkylsulfonylimide ion of the above chemical formula (1) can form a salt with a cation, and may be added as a perfluoroalkylsulfonylimide salt in the electrolyte solution in the electrolytic polymerization method. The cation that forms a salt with perfluoroalkylsulfonylimide may be constituted of one element such as Li^+ , or may be constituted of plural elements. The aforesaid cation is not particularly limited as long as it can form a perfluoroalkylsulfonylimide ion as a monovalent positive ion and is a Lewis acid that can be dissociated in an electrolyte solution.

When the aforesaid cation is a metal element, an element selected, for example, from alkali metals such as lithium can be used. Also, when the aforesaid cation is a molecule, alkylammonium represented by tetrabutylammonium and tetraethylammonium,

pyridinium, imidazolium, and the like can be used, for example.

The perfluorosulfonylimide ion contained in the electrolyte solution of the electrolytic polymerization method in the production method of the present invention can form various salts by a combination of perfluoroalkylsulfonylimide ion serving as a base component and a cation serving as an acid component, as described above. Since perfluorosulfonylimide salt can be easily dissociated in a solution and is easily available, bis(perfluoroalkylsulfonyl)imide lithium such as bis(trifluoromethyl)sulfonylimide lithium and bis(pentafluoroethylsulfonyl)imide lithium, and tetrabutylammonium salt, pyridinium salt, or imidazolium salt of bis(perfluoroalkylsulfonyl)imide such as bis(trifluoromethyl)sulfonylimide and bis(pentafluoroethylsulfonyl)imide are preferable.

The content of the aforesaid perfluoroalkylsulfonylimide ion in the electrolyte solution in the electrolytic polymerization method is not particularly limited; however, the aforesaid perfluoroalkylsulfonylimide ion is preferably contained in an amount of 1 to 40 wt%, more preferably 2.8 to 20 wt%, as perfluoroalkylsulfonylimide salt so as to ensure a sufficient ion conductivity of the electrolyte solution.

In the method of producing an electrically conductive polymer of the present invention, the electrolyte solution used in the electrolytic polymerization method can further contain other known additives such as polyethylene glycol and polyacrylamide.

Here, in the method of producing an electrically conductive polymer of the present invention, the working electrode is not particularly limited as long as it can be used for electrolytic polymerization, so that an ITO glass electrode, a carbon electrode, a metal electrode, and the like can be used. The aforesaid metal

electrode is not particularly limited as long as it is an electrode mainly made of a metal; however, an electrode of a single metal element or an electrode of an alloy made of metal elements selected from the group consisting of Pt, Ti, Ni, Au, Ta, Mo, Cr, C, and W can 5 be used. It is especially preferable that the metal kind contained in the metal electrode is Ni or Ti because the electrode is easily available. Here, as the aforesaid alloy, for example, trade names "INCOLOY alloy 10 825", "INCONEL alloy 600", and "INCONEL alloy X-750" (the above being manufactured by Daido Special Metal Co., Ltd.) can be used. Also, in order to increase the swelling contraction in a solvent, a Pt 15 electrode is preferable and, when large swelling in a good solvent is desired, it is preferable to use an ITO glass electrode or an ITO electrode using a plastic substrate.

The filmy object of the present invention contains, as a 20 film-forming component, an electrically conductive polymer obtained by the electrolytic polymerization method. The aforesaid filmy object can perform doping and dedoping of functional molecule ions by control of applied voltage because of containing an electrically conductive polymer obtained by the electrolytic polymerization 25 method as a film-forming component. The aforesaid filmy object may contain components other than the electrically conductive polymer, such as metal mesh, metal coil, porous polymer, porous ceramics, porous glass, and polymer as long as the filmy object does not lose functions as a functional film. In the aforesaid filmy object, it is preferable that the base resin is an electrically conductive 30 polymer, and it is further preferable that all the resin components of the aforesaid filmy object are electrically conductive polymers obtained by the electrolytic polymerization method, because then the doping and dedoping of functional polymer ions by application of voltage will be easy. In particular, it is preferable that, in the

5 aforesaid filmy object, all the resin components are electrically conductive polymers obtained by the electrolytic polymerization method and, in the electrolytic polymerization method, the monomer is pyrrole and/or a pyrrole derivative, and are electrically conductive polymers obtained by the electrolytic polymerization and containing perfluoroalkylsulfonylimide ion represented by the formula (1):



10 (here, n and m are arbitrary integers.) in the electrolyte solution, because then the filmy object can absorb and desorb larger functional molecule ions.

15 The filmy object of the present invention is obtained by the electrolytic polymerization method. In order to use it for an intended purpose, the filmy object can be peeled off from the working electrode that was used for the electrolytic polymerization, or may be used by being combined with the working electrode. In the case of peeling off the aforesaid filmy object from the working electrode, the aforesaid filmy object can be obtained, for example, by allowing the electrically conductive polymer film formed on the working electrode by the electrolytic polymerization to swell with a good solvent such 20 as acetone, and peeling off the electrically conductive polymer film with use of forceps or the like.

25 If it is required for use of the filmy object of the present invention as a functional film that the aforesaid filmy object is made to contain a substance (functional molecules) for exhibiting a function as a functional film of a pharmaceutical agent, an agricultural chemical, an insecticide, an organism avoiding agent, or the like before using the functional film, the aforesaid filmy object can contain the aforesaid substance in an ion state by application of voltage to the aforesaid filmy object in a good solvent into which the 30 aforesaid substance has been dissolved. Also, the filmy object can

incorporate functional molecules by immersion of the filmy object of the present invention into a solution containing the functional molecules or by exposure of the filmy object of the present invention to a gas containing the functional molecules.

5

EXAMPLES

Hereafter, Examples and Comparative Examples of the present invention will be shown; however, the present invention is not limited to the following.

10

(Example 1)

15

Polypyrrole which is a monomer of electrically conductive polymer and a salt described in Table 1 were dissolved into a solvent described in Table 1 by a known agitation method, so as to prepare an electrolyte solution having a monomer concentration of 0.25 mol/l and with the dopant salt of Table 1 having a concentration of 0.2 mol%. With this electrolyte solution, electrolytic polymerization was carried out by the constant-current method with the polymerization current density being a value described in Table 1 using a commercially available electrode having a metal kind described in Table 1 as a working electrode and using a commercially available Pt electrode as an opposing electrode. By this electrolytic polymerization, an electrically conductive polymer film having an electric conductivity and a film thickness described in Table 1 was obtained on the working electrode. The aforementioned electrically conductive polymer film having a working electrode form was immersed into acetone, and the electrically conductive polymer film was peeled off from the working electrode with use of commercially available forceps to obtain a filmy object of Example 1.

20

25

(Examples 2 to 8)

30

Filmy objects of Examples 2 to 4 were obtained in the same

manner as in Example 1 except that the electrolytic polymerization was carried out with the salt, the solvent, the electrode, and the current density described in Table 1. Here, TBA represents tetrabutylammonium.

5 **(Comparative Example)**

A filmy object of Comparative Examples 1 was obtained in the same manner as in Example 1 except that the electrolytic polymerization was carried out with the salt, the solvent, the electrode, and the current density described in Table 1.

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Comparative Example 1
Polymerization condition	Salt	(CF ₃ SO ₂) ₂ NLi	(CF ₃ SO ₂) ₂ NLi	(CF ₃ SO ₂) ₂ NTBA	(CF ₃ SO ₂) ₂ NTBA	CF ₃ SO ₂ TBA
	Solvent	Methyl benzoate	Methyl benzoate	Methyl benzoate	Methyl benzoate	Methyl benzoate
	Electrode	Ti	Ni	Ti	Pt	Ti
	Current density (mA/cm ²)	0.2	0.2	0.2	0.2	0.2
	Polymerization time (hr)	4	4	4	4	4
Characteristics	Electric conductivity (S/cm)	75.4	34.8	129.0	114.4	107.7
	Film thickness (μm)	19.0	26	32	17	20
	Swelling ratio (%)	Acetone	97	97	109	132
		Propylene carbonate	85	85	92	120
						3

(Evaluation)

Each of the **filmy objects of electrically conductive polymer** obtained in Examples 1 to 4 and Comparative Example 1 was cut out to have a length of about 30 mm, a width of about 30 mm, and a thickness of about 0.03 mm to prepare a test piece, and the swelling ratio was measured.

[Swelling ratio]

Each of the **test pieces of the *filmy objects obtained in Examples 1 to 4 and Comparative Example 1*** was prepared for the number of solvents for immersion and, with respect to each test piece, the length and the width of the actual test piece were measured. Subsequently, into acetone and polycarbonate, each of the test pieces

of the filmy objects obtained in Examples 1 to 4 and Comparative Example 1 was immersed each for six minutes so that each test piece might be immersed into one kind of solvent. With respect to each immersed test piece, the length and the width of the test piece after immersion into the solvent was measured. The swelling ratio was calculated with use of the following formula. Here, the area of the film surface of the test piece is a product of the length and the width in each test piece.

10 **Swelling ratio (%) = [(film area of test piece after immersion) - (film area of test piece before immersion)] / (film area of test piece before immersion) × 100**

The filmy object containing the electrically conductive polymer of Examples 1 to 4 is an electrically conductive polymer film obtained by the electrolytic polymerization method, and swelled by 30% or more in the solvent. Particularly, the filmy object of Example 3 and Example 4 swelled by 100% or more, and exhibited a state as a gel polymer that has swollen to an extremely large extent. In contrast, the filmy object of Comparative Example 1 is a conventional filmy object containing an electrically conductive polymer obtained by the electrolytic polymerization method, and had a swelling ratio of an extremely low value as compared with 30%. The filmy object of the present invention swells largely by a solvent, so that the molecular movement in the filmy object having a gel form is easy as compared with a film having a solid form. Therefore, adsorption and release of functional molecule ions is easy as a functional film. When the swelling ratio of the filmy object of the present invention is a value further higher than 30% as in the filmy object of Examples 1 to 4, adsorption and release of functional molecule ions is further easier.

The *filmy object* of Example 1 is a *filmy object* of electrically

conductive polymer obtained by the electrolytic polymerization method, and a view of an electron microscope photograph of the film surface thereof is shown in Fig. 1. The right side of Fig. 1 shows an electron microscope photograph of the surface of the film surface on the electrolyte solution side, and the left side shows an electron microscope photograph of the surface of the film surface on the electrode side. As shown in Fig. 1, the filmy object of Example 1 of the present invention has a porous structure having a sponge form and has a large specific surface area, so that even large functional molecules or ions can be easily diffused into the inside of the film. In contrast, the filmy object of Comparative Example 1 is provided with a flat film surface as shown in Fig. 2. Moreover, since the filmy object of Comparative Example 1 is provided with a flat film surface both on the front side and on the back side, it is not easy even for large functional molecules or ions to be diffused into the inside of the film.

The electron microscope photographs of Figs. 1 and 2 are photographs that have been captured with a magnification of 1000 times with use of a known image-capturing method that captures images under a high vacuum by allowing gold to adhere to the sample by a known sputtering method with use of a scanning electron microscope (trade name of "S-3000N", manufactured by Hitachi High Technology Co., Ltd.). Fig. 1 is a view obtained by cutting a part near the center out into a square form without performing special image-processing treatments and joining a photograph of the film surface on the electrolyte solution side and a photograph of the film surface on the electrode side.

INDUSTRIAL APPLICABILITY

The filmy object of the present invention can be used as a

functional film and can be used in various modes in accordance with the intended object. For example, the filmy object of the present invention can be suitably used as a supporting film having a slow-releasing property that releases drugs represented by pharmaceutical agents, agricultural chemicals, or drugs for home use (insecticide or the like of ticks, cockroaches, and mosquitoes), an odor releasing electrode, a drug releasing part of a catheter that locally transmits drugs, and a drug releasing part of an automatic drug adding system.

Also, the filmy object of the present invention can adsorb and release functional molecule ions, so that the filmy object can be used suitably as a functional separation film for collection of trace substances having a highly added value, for collection and removal of harmful substances, or for a precision separation system that can be controlled to adsorb and release by electrical control.

The filmy object of the present invention can adsorb and release functional molecule ions, so that the filmy object can be used suitably also as a base material for an optical electrode of a photocell, a touch panel, an opposing electrode of a dye-sensitizing type solar cell, a reaction field of trace organic synthesis, a field effect transistor, a supporting film of a catalyst, an electrode catalyst represented by a fuel cell, and a filmy controlling part that electrically controls the composition of a solution.

The filmy object of the present invention can adsorb and release functional molecule ions, so that the filmy object can be used suitably also as a water-purging film, an electrode of a flexible display represented by an electric paper, a substance transporting film, a chemical motor, and a molecular sieve.

The filmy object of the present invention can generate swelling such that, when the filmy object is immersed in a good solvent, the

5 **film surface area of the filmy object increases by 30% or more as compared with the area before the immersion, so that the filmy object can be used suitably for various purposes by utilizing the swelling characteristics. For example, the filmy object of the present invention can be used suitably also as an artificial skin, a wall paper that changes the sense of touch, a valve that utilizes the swelling contraction to a solvent, an intelligent gate, and a shock absorber.**

10 **The filmy object of the present invention can be used suitably as a polymer electrolyte by immersion into an electrolyte solution after dedoping by utilizing the swelling characteristics thereof.**

15 **The filmy object of the present invention can generate swelling such that, when the filmy object is immersed in a good solvent, the film surface area of the filmy object increases by 30% or more as compared with the area before the immersion, and moreover, the aforesaid filmy object is a filmy object having a plurality of holes that are formed in a porous form on the film surface, and the shorter diameter of the holes at the opening part is 0.5 μm or more at the time of being dry. Since the filmy object has holes also, the surface area at the film surface will be large, so that the filmy object can be used suitably as a sensor represented by an electric nose, an odor sensor, a gas sensor, a gustatory sensor, a pH sensor, a humidity sensor, and a tactal sensor. Also, since the aforesaid filmy object has holes also, the surface area at the film surface will be large, so that the filmy object can be used suitably also as an electrode of a**

20 **large-capacity secondary battery and a capacitor.**

25